UNDERSTANDING THE SNAKE ENCOUNTERS IN HUMAN DOMINATED AREAS OF NORTH BENGAL: A CASE STUDY OF SILIGURI, WEST BENGAL

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Abstract: Changes in major land use patterns resulting in deforestation is increasing the probabilities of man-animal conflicts. In special context to snakes, snakes are finding their refuge around human habitation unlike other big animals, due to availability of food. This is resulting in incidents of snake bites. To understand this threat, identifying major drivers of human-snake encounters are needed. The current research is a preliminary approach towards knowing pragmatic factors for snake occurrence in human dominated landscape in Siliguri town of West Bengal (India). Occurrence of snakes (N=51) in town and villages were recorded to model the dependency on ecological and anthropological factors, i.e. Distance from forests and water sources, precipitation of wettest quarter, terrain elevation and temperature of wettest quarter using multinomial logistic regression. Model Ψ(Pr~Forest+Water+Bio16+Alt) found as best model (AIC~91.81) among seven regression models, which suggested negative significance of the occurrence probability of snakes with mentioned variables in human dominated areas, depicted as distance from forests (β -0.60±0.10; $p<<0.05$), distance from water sources (β -0.33±0.07; $p<<0.05$), precipitation of wettest quarter (β -0.50±0.12; $p<0.05$) and terrain elevation (β -0.33±0.12; $p<0.05$). Spectacled cobra has the relatively highest encounters among all observations.

IndexTerms **- Snakes, Human dominated areas, Human-snake conflicts, Snakebite, North Bengal.**

I. INTRODUCTION

Human-Snake conflict is one of the global threats to snake diversity. Anthropogenic activities in natural habitats are the key factors affecting the expansion of ophiofaunalen counters in human dominated areas. Though, snakes are considered to be a part of Indian culture since ancient era, snakebite and snake encounters are a type of environmental health risk in India. However, there is no reliable national or regional statistic available on the magnitude of snakebite incidences in India [(1)]. Previously, hospital database has been assessed for surveying global snakebite mortalities in year 1954 [(2)]. There are around 3000 species of globally distributed snakes, among which 500 species are venomous [(1)]. The major families of venomous snakes include family *Elepidae*, *Viperidae* and *Hyrdrophidae*, comprises around 52 species in India. There are five venomous snake species in India, which are Spectacled cobra (*Najanaja*), Common krait (*Bungaruscaeruleus*), Saw scaled viper (*Echiscarinatus*), Russell's viper (*Daboiarusseli*) and King cobra (*Ophiophagushannah*). Around 45,900 deaths (99% CI: 40,900-50,900 deaths) are being caused by snakebites in India [(3)]. The reasons for the snakebite mortality in human dominated areas of tropical developing countries include scarcity of antivenoms, poor health services and difficulties with rapid access to health centers [(4)].With the huge numbers of human and snake mortality and morbidity, there is need to assess the ecological and anthropogenic factors, which drive the occurrence of snakes in human dominated areas.

The current study is a preliminary approach to assess these independent factors with statistical approval. Siliguri town of West Bengal state has been surveyed as the model for the study. According to previous studies, West Bengal has 40 among 8,330 human deaths, being caused by snakebites in year 2001-03. In the year 2005 total number of deaths attributed to snake bites were 3.5 per 1,00,00 individuals [(3)].

II. METHODS

The study area is politically known as Siliguri town (26.812°N 88.316°E – 26.659°N 88.499°E) in district Darjeeling of West Bengal state India (*Figure1*). The study has been performed in Siliguri and adjoining areas, bears 24°C annual mean temperature and 3620mm annual mean rainfall [(5)]. According to Köppen-geiger climate classification, the study area is a part of "Cwa" type of climate, elaborates as warm temperate climate, winter dry precipitation and hot summer temperature [(6)]. Sal (*Shorearobusta*) is one of the major dominant plant species in the forest landscape, as it has around 120meters elevation from mean sea level [(5)].The study area situated in Himalayan footplains which is surrounded by Mahananda Wildlife Sanctuary and Senchal Wildlife Sanctuary in north, Gorumara National Park and Chapramari Wildlife Sanctuary in east and Baikanthapur Reserve Forest in south east [(7)]. The town and adjoining areas have relatively high human density 2000-6000per square kilometers [(8)].

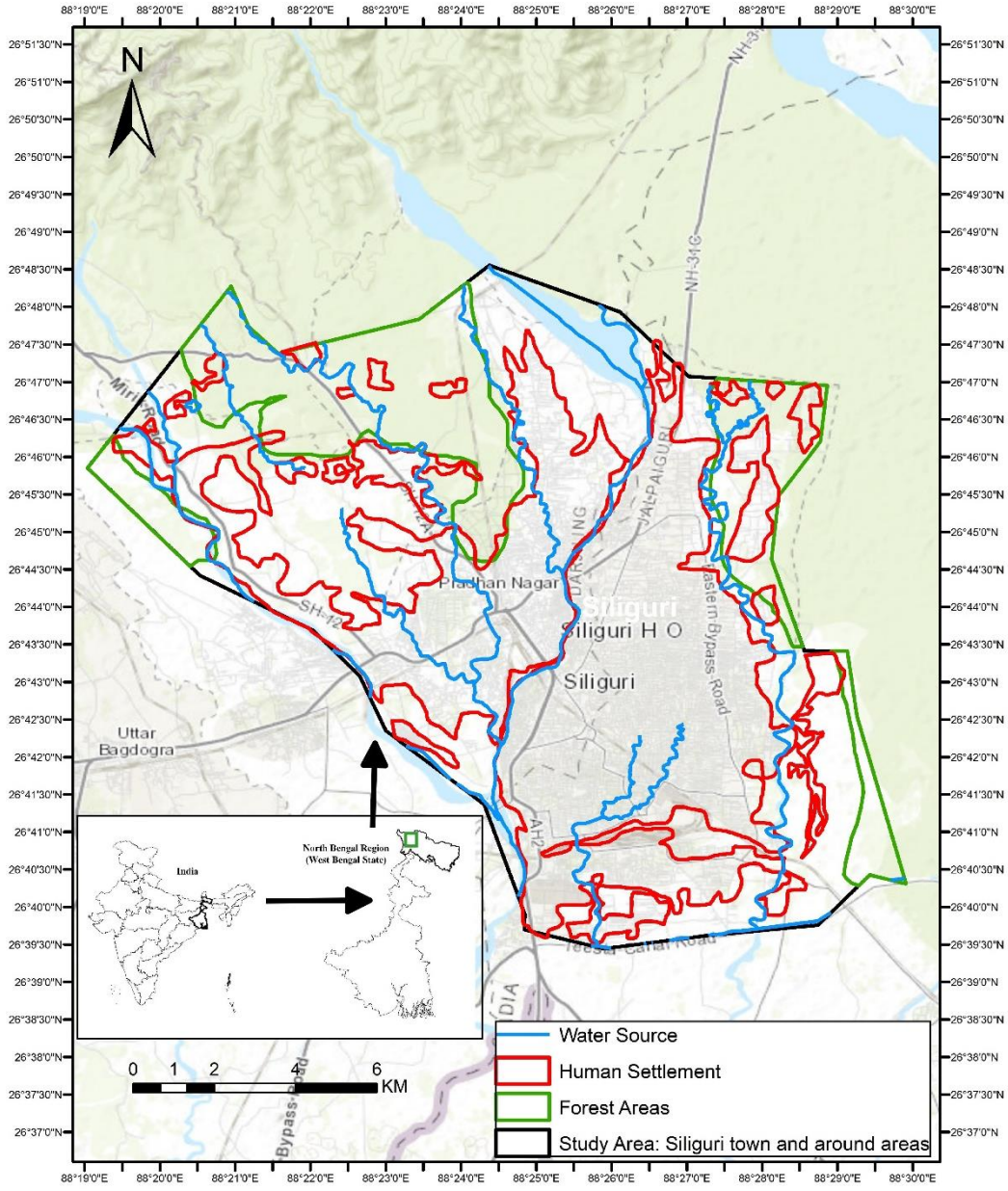

Figure1: Study area (Siliguri and peripheral areas 26.812°N 88.316°E – 26.659°N 88.499°E)

This is an approach to quantify the dependency of ophiofaunal occurrence on various environmental and anthropogenic variables; we have collected their respected geographical coordinates (Degree decimal format) using GPS *Garmin etrex 30X* and *Locus map version 3.36.0* android application during July 18, 2018 to September 18, 2018. The study tenure has been opted because there are highest human mortalities in the same period in India [(3)], so further results can be associated with previous studies. The information of snake encounters were acquired from forest department and local snake rescuers. The occupancy of snakes (N=51) was considered with live sightings only. None of the snakes were harmed or touched by the observers during data collection. Distance from forest areas (0.017±0.017), distance from water sources (0.005±0.004), mean

precipitation of wettest quarter (2233.91±68.39), mean temperature of wettest quarter (28.34±0.07) and elevation (132.88±18.39) were considered as independent variables to assess the dependency of snake occurrence in study area. Forest areas and water sources were manually mapped using *Google earth pro version 7.3.2.5491*. Distance from forest areas and water sources were analyzed using Eulidean distance tool of *Arcmap version 10.2*, which were manually validated by the observers. Precipitation and temperature of wettest quarter and elevation were acquired from Worldclim2 database [(9)]. Two type of resolution of raster datasets were 60meters square (Distance from forest areas, distance from human settlements and distance from water sources) and 800meters square (Precipitation of wettest quarter, temperature of wettest quarter and elevation). As the study has been organized in the monsoon, the climatic variables of study duration were represented by wettest months only.WGS1984 projection was used for all geographical processing.

The maxent logistic regression algorithm has been performed for assessing snake occurrence values using *MaxEnt version 3.4.1*. 80% presence information of various snakes' species was utilized to model 23-fold cross validation method, rest 20 percentage were used as test data sets to validate the model. AUC (Area under curve) was calculated to know the accuracy of maximum entropy model. Mean of 10 percentile presence area of MaxEnt output was assessed to identify the threshold of presence for the species. Total seven multinomial logistic regression models were run using *R studio version 1.1.463*[(10)].The species occurrence values were extracted from outputted MaxEnt model with *Arcmap version 10.2*, which classified into five ordinal categories (0-0.2 as 1, 0.2-0.4 as 2, 0.4-0.6 as 3, 0.6-0.8 to 4 and 0.8-1 as 5), suggesting ascending occurrence probability. Independent variables were converted into *z* score using average and standard deviation to make data standard normal distribution. Total seven logistic regression models were run for the comparison. Models were fitted using a maximum likelihood method [(11)], using backwards elimination to select the variables in the final models [(12, 13, 14)] with AIC (Akaike's information criterion) and changes in scaled deviance [(15)].Contributions of each variables were analyzedon basis of AIC and *p* value of model.

IV. RESULTS AND DISCUSSION

According to own observation and previous literature, there are around 54 ophiofaunal species recorded from North Bengal region. Out of 54 species, 16 venomous, 12 mildly venomous and 26 non-venomous species are recorded [(16)]. As per previous surveys and studies on human psychology in special aspects to snakes, most of the common people (from non biological background and inexperienced agricultural folks) consider all snake species as venomous due to lack of knowledge (*pers. Obs.*). In order to avoid being victim to snake bites, people used to kill snakes, sighted in and around human settlements. Efforts were made to rescue these snakes with the help of local forest departments, to avoid human –snake conflicts. 10 species of snakes (N=51) were encountered in human dominated areas, including three highly venomous (N=26), one mild venomous (N=4) and six non-venomous snakes (N=21). Spectacled cobra is the frequently encountered species in the study area (*Figure2; Figure3*).

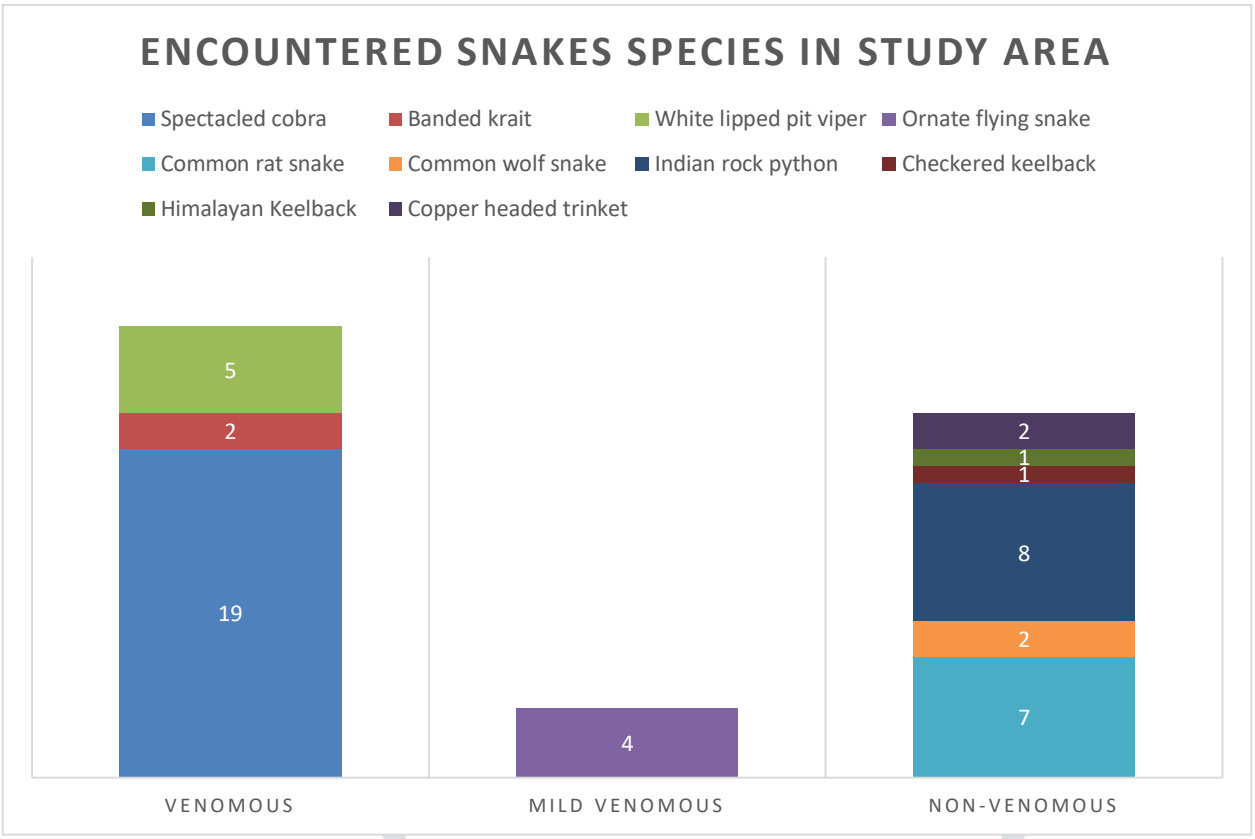

Figure2: Encountered snake species in the study area

Relations between variables and occurrence of snakes were correlated in and around human settlement of Siliguri town. Vector mapping of water sources and forest areas were found 94% accurate, assessed with ground validation. The errors can be due to difference in imagery dates of Google earth and sampling dates. We calculated total areas covered by forests and human settlements and found it to be 200km^2 and 80km^{2}respectively. Similarly, length of water sources such as rivers and nalas were found to be 125km.AUC of the maximum entropy model is assessed 0.76, suggests higher accuracy of model. With the results of multinomial logistic regression, we found model Ψ(Pr ~ Forest+Water+Bio16+Alt)(AIC 91.81; *p* value<0.05; Cox & Snell $R^2$0.58; Nagelkerke $R^2$0.63)as the best suitable model among seven regression models (*table1*). The ascending selections of variables were performed on basis of responding AIC of each variables.

Table1: Compared multinomial logistic regression models

Model	AIC	Cox and Snell R^2	Nagelkerke R^2	*p* value
Ψ(Pr~1)	128.10	0.00	0.00	
Ψ(Pr~Forest)	124.60	0.11	0.11	0.03780 (<0.05)
Ψ(Pr~Forest+Water)	104.20	0.42	0.46	0.00038 (<0.05)
Ψ(Pr~Forest+Water+Bio16)	97.88	0.51	0.56	0.00029 (<0.05)
Ψ(Pr~Forest+Water+Bio16+Alt)	91.81*	0.58	0.63	0.00025 (<0.05)
Ψ(Pr~Forest+Water+Bio16+Alt+Bio8)	93.02	0.59	0.64	0.00054 (<0.05)

**denotes that the mode is opted as best suitable model as per lowest AIC*
Abbreviations: Forest: Distance from forest areas; Water: Distance from water sources; Bio16: Mean precipitation of wettest quarter; Bio8: Mean temperature of wettest quarter; Alt: Terrain elevation.

According to best model, distance from forest areas (p<<0.05), distance from water sources (p<<0.05), precipitation of wettest quarter (p<0.05) and elevation (p<0.05) are very significantly playing the role for the occurrence of the snakes in human dominated areas (*table2*).These variables are found negatively correlated with the occurrence classes of snakes in human settlements. It suggests that higher the distance from forest lower is the occurrence probability of snakes. Similarly, the increasing distance from water sources, increasing precipitation and increasing altitude also shows the decreasing probability of species occurrence in human inhabited areas. These independent factors are found ecologically and statistically significant with occurrence of snake probability.

Table2: Dependency of snake occurrence on dependent variables

Coefficients	β estimate	Std. error	AIC	Deviance	t value	*p* value
Intercept	3.89	0.08	91.81	14.28	49.26	<<0.05*
Forest	-0.60	0.10	118.89	25.26	-5.95	<<0.05*
Water	-0.33	0.07	107.34	20.14	-4.34	<<0.05*
Bio16	-0.50	0.12	106.17	19.68	-4.17	<0.05*
Alt	-0.33	0.12	97.88	16.73	-2.81	<0.05*

** denotes that the variables are significantly related*

Abbreviations: Forest: Distance from forest areas; Water: Distance from water sources; Bio16: Mean precipitation of wettest quarter; Alt: Terrain elevation.

Decreasing ecological resources are dramatically changing the ecosystem globally, includes the impacts on ophiofaunal diversity too. In context to Siliguri town, it is an emerging metropolitan city of North Bengal region, which is expanding extensively since year 2000. The anthropogenic acts are major key factors, which are altering the natural habitats. These habitat modifications is providing suitable condition for snake species in human dominated areas. There is a limited availability of thermally suitable sites and lack of prey in forests, which is easily accessible by the snakes in human dominated landscapes [(17)]. Overlap of human dominance and modified snake habitats is escalating the conflicts between snakes and human. Our study depicts the similar results, where the probability of human-snake conflicts is higher in human areas, which is ecologically affected by forest and water sources, rainfall andterrain elevation. Still there is needed to do fine scale study on the aspect to assess more ecological and anthropological variables, which drive the probability of snake occurrence in anthropoid areas.

Figure 3: Spectacled cobra in one of the house in Siliguri

III. CONCLUSION

On the basis of our results and the foregone discussion it becomes clear that there should be a set norm and legal binding on the distance between the human settlements and the boundaries of the forest. This distance can be decided on the basis of diversity of snake species encountered in the particular area. Knowledge of diversity will enable the government officials and the researchers to know size, food preference, size of the territory and the behavioural pattern related to each species. If human settlements are must near the forest then the settlements on high terrain would help in reducing the number of man –snake encounters as our studies reveal that the occurrence of snakes on the high terrain was significantly low. It is further evident from the results that very close settlement around the major water resources should be avoided, water supply should be taken over by the government bodies as a prime responsibility and frequent visits to water bodies should be avoided. Knowledge about the relation between rate of precipitation and occurrence of snakes would help in educating the rural folks in avoiding the tracks used by the snakes mainly during dry season.

All the variables studied in the present investigation presented good results. These results would help in reducing the man-snake conflicts and encounters. On one hand it will help in saving many innocent human lives and on the other hand it will protect the much needed snake diversity, an important link in forest food chain.

IV. ACKNOWLEDGMENT

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